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[Application Fee] 21,000 yen

[Submission Items]

[Item] Specification 1

[Item] Drawings 1

[Item] Abstract 1

[Document Title] Specification

[Title of Invention] OPTICAL ACTUATOR

[Claims]

[Claims 1] An optical actuator comprising:

a focusing lens for focusing a laser beam on a information disk;

a holder for holding said focusing lens;

a focusing coil for driving said focusing lens in an axial direction of said laser beam;

tracking coils for driving said focusing lens in a radial direction of said information disk;

tilting coils for pivotally rotating said focusing lens on a center axis orthogonal to said beam axial direction;

a pair of support members each disposed on each of two opposing lateral sides of said holder; and

a plurality of linear elastic members each of the same length, an end thereof being connected to each of at least three fixing element that are disposed in an approximately circular arc on each of said support members; wherein

by said linear elastic members being connected to said pair of support members, said holder is supported reciprocably in said beam axial direction and said disk radial direction, and rotatably on said axis.

[Claims 2] The optical actuator according to claim 1, wherein

tracking coils are disposed on lateral sides of the holder perpendicular to said center axis; and

a side of said tracking coils is disposed outside a magnet provided opposing said tracking coils.

[Claims 3] The optical actuator according to claim 2, wherein among said linear elastic members connected to each support members, the linear elastic members which are disposed in center position pass through the tracking coils.

[Claims 4] The optical actuator according to claim 1, wherein one tracking coil is disposed on a lateral side of the holder facing a permanent magnet.

[Detailed Description of the Invention]

[0001]

[Technical field to which the Invention Belongs]

The present invention relates to information recording and playback devices that form a beam spot on a recording side of an information disk. More particularly, it relates to devices for driving an optical actuator to form a beam spot in accurate position.

[0002]

[Description of the Related Art]

An optical actuator drives, which drive a focusing lens that focuses a beam spot on a information disk such as a DVD (digital versatile disk) or a CD (compact disk), by driving the focusing lens in the perpendicular direction (focusing direction) with respect to the disk and the disk radial direction (tracking direction), control the beam spot so that it focuses accurately on the pit line. Further, if leaning (hereinafter referred to as tilt) of the optical axis of the focusing lens with respect to the disk face occurs due to disk wobble or disk warpage caused by the disk rotating, the optical actuator system performs tilt control by pivotally rotating the focusing lens on an axis along the tangential direction of the disk.

[0003]

An example of an optical actuator that drives the focusing lens in the focusing direction, tracking direction and tilting direction is described in Patent Document 1. Fig. 10 is an oblique view illustrating the optical actuator disclosed in the Patent Document 1. An objective lens 101 is fixed to a lens holder 102. Provided on a lateral side of the lens holder 102 are six strip-metal blade springs 103a through 103c, and 103d through 103f. Print coils 104a and 104b are fixed to another lateral side of the lens holder 102. A base 105 is provided with a suspension holder 106 for supporting the lens holder 102, and permanent magnets 107a through 107d for controlling the lens holder 102. The strip-metal blade springs 103a through 103c, and 103d through 103f are connected to the suspension holder 106 by suspension wires (linear elastic members) 108a through 108c, and 108d through 108f, respectively, to support the lens holder 102 on the base 105. The print coil 104a is interposed between the permanent magnets 107a and 107b, and the print coil 104b is interposed between the permanent magnet 107c and 107d.

[0004]

When a current is supplied to built-in focusing coils (not shown) in the print coils 104a and 104b so as to generate identically oriented electro-magnetic forces, the lens holder 102 is controlled in the optical axis direction Fo (hereinafter alternatively referred to as focusing direction). Further, when a current is supplied to built-in tracking coils (not shown) in the print coils 104a and 104b so as to generate identically oriented electro-magnetic forces, lens holder 102 is controlled in a tracking direction Tk that is in a radial direction of the optical recording medium. Still further, when a current is supplied to the focusing coils (not shown) so as

to generate oppositely directed electro-magnetic forces, the lens holder 102 undergoes rotational moment on an axis in the tracking direction Tk. As a result, the lens holder 102 is controlled in the tilting direction Ti. Fig. 11 is a sectional view illustrating the lens holder being rotated in the tilting direction Ti. When the electro-magnetic forces are generated oppositely in the focusing coils (not shown), the strip-metal blade springs 103a and 103c are warped and twisted by the same amounts in opposite directions.

As a result, the center of the strip-metal blade springs 103b will be the center O of rotation in the tilting direction Ti, and the lens holder 102 will be rotated by an angle θ and driven in the tilting direction Ti. The above-described controls allow for the lens holder being driven in the three directions, that is, the focusing direction Fo, the tracking direction Tk, and the tilting direction Ti.

[0005]

[Patent Document]

Japanese Patent Laid-Open No. 2001-297460

[0006]

[Problem that the Invention is to Solve]

The optical actuator illustrated in Fig. 10 uses the six strip-metal blade springs 103a through 103f as the contact points for the suspension wires 108a through 108f alongside the lens holder 102. As a result, the problems of higher cost for parts and larger number of assembly steps have been unavoidable. Also, because of the six strip-metal blade springs 103a through 103f are used as a support mechanism for the lens holder 102, there have been problems in that fluctuations in product quality have occurred, and consequently fluctuations

in the tilting operation have occurred.

[0007]

The present invention has been made to resolve the problems faced with in the prior art, and primary objects of the invention are to drive an optical actuator stably in three directions, that is, in the focusing direction Fo, in the tracking direction Tk, and in the tilting direction Ti, and to provide an easy-to-manufacture optical actuator.

[0008]

[Means for Solving the Problem]

An optical actuator related to the invention includes:

a focusing lens for forming a laser beam on a information disk;

a holder for holding the focusing lens;

focusing coils for driving the focusing lens in an axial direction of the laser beam;

tracking coils for driving the focusing lens in a radial direction of the information disk;

tilting coils for pivotally rotating the focusing lens on a center axis orthogonal to the beam axial direction;

a pair of support members each disposed on each of two opposing lateral sides of the holders; and

a plurality of linear elastic members each of the same length, an end of thereof being connected to each of at least three fixing elements that are disposed in an approximately circular arc on each of the support members; wherein

by the linear elastic members being connected to the pair of support members, the holder is supported reciprocably in the beam axial direction and the disk radial direction, and rotatably on the aforementioned axis.

[0009]

[Embodiments of the Invention]

Fig. 1 is an oblique view illustrating an optical actuator in a preferred embodiment according to the present invention. Fig. 2 is an exploded oblique view illustrating a configuration of a holding member 15 and a moving member 14 of the optical actuator illustrated in Fig. 1. Also Figs. 3A and 3B are views illustrating the top side and a lateral side of the optical actuator illustrated in Fig. 1 and Fig. 2. As illustrated in Fig. 2, the holding member 15 comprises a yoke 7, permanent magnets 6a and 6b, and a circuit board 8. The permanent magnets 6a and 6b are magnetized in the thickness direction and attached on the yoke 7 so that their identical poles face each other. The yoke 7 is formed with protrusions 7a and 7b, and a through-hole 7h, which a laser beam passes through.

[0010]

The moving member 14 comprises a focusing lens 1, a holder 2, a focusing-control coil 3, tracking-control coils 4a, 4b, 4c and 4d, and tilting-control coils 5a and 5b. The focusing lens 1 is fixed to a top surface of the holder 2, which focuses the laser beam, passing the through-hole 7h, onto an information disk. The holder 2 is integratedly provided with the focusing-control coil 3, the tracking-control coils 4a through 4d, and the tilting-control coil 5a through 5b. The focusing-control coil 3 is wound around the holder 2, and the tilting control coils 5a and 5b are retained by a pair of poles 20a and 20b fixed to the bottom of the holder 2. The focusing-control coil 3, and the tilting-control coils 5a and 5b are arranged so that the center axes of each coil and the optical axis of the focus lens 1 orient in the same direction. Also the

tracking-control coils 4a and 4b are arranged on the lateral side of the holder 2. As illustrated in Fig. 2, on a lateral side of the holder 2, positioning members 12a and 12b that dispose the tracking-control coils 4a and 4b in the appropriate positions are provided. In the same way, the tracking control coils 4c and 4d are arranged on the opposite lateral side of the holder 2 through positioning members 12c and 12d (not shown). The holder 2 is formed with through-holes 2a and 2b that pass through the protrusions 7a and 7b formed on the yoke 7.

[0011]

Each of a pair of support members 2c and 2d is provided on a respective lateral side of holder 2. Each of the support members 2c and 2d is provided with fixing elements 29a through 29c, and 29d through 29f respectively, to which one end of the conductive linear elastic members 9a through 9c, and 9d through 9f is connected. The linear elastic members 9a through 9f are fixed to the support members 2c and 2d by fixing elements 29a through 29f, and also electrically connected to the beginning and end of each of three control coils. The other end (not shown) of linear elastic members 9a through 9f is connected electrically to the circuit board 8 through the fixing elements disposed in a circular arc on the lateral side of the yoke 7. Then the linear elastic members 9a through 9f support the moving member 14 movably in each of three control directions, that is, the focusing direction Fo, the tracking direction Tk, and the tilting direction Ti, and also supply a control current to each of the control coils.

[0012]

As illustrated in Fig. 4, each of the fixing elements 29a through 29c, and 29d through 29f of support members 2c and 2d (and each of corresponding fixing elements of the yoke 7) is arranged

in the circular arcs shown by the dotted lines. That is, the linear elastic members 9a through 9c and 9d through 9f are arranged on cylindrical surfaces each with a different center, and support the holder 2. Each cylindrical surface may have the same center.

[0013]

Hereinafter the operation of the optical actuator illustrated in Figs. 1 through 4 will be explained. Focusing error of in a focusing spot being formed on the information disk, and tracking displacement of the focusing spot with respect to the desired track are detected by a well-known method such as the astigmatic method or DPD (differential phase detection). In that situation, by supplying a signal proportional to the focusing error and the tracking displacement to the focusing coil 3 and the tracking coils 4a and 4b, each of the coils is subjected a force, in the focusing direction Fo and the tracking direction Tk, generated by interaction with the magnetic field formed by the permanent magnets 6a and 6b. Consequently the focusing control and the tracking controls are performed so as to shift reciprocably the focusing lens proportional to the focusing error and the tracking displacement.

[0014]

At the same time, when tilt of the laser beam axis with respect to the disk-surface occurs due to disk warpage, or to disk wobble of the information disk caused by its rotation, the tilt amount is detected using a well-known method, then a signal proportional to the tilting displacement is supplied to the tilting control coils 5a and 5b. By supplying a drive current to the tilting-control coil 5a to drive it in the direction +Fo (or direction -Fo), and to the tilting-control coil 5b to drive it in the opposite direction -Fo (or direction +Fo), the holder 2 is rotated on the center axis orthogonal to the focusing direction Fo and the tracking direction

Tk (an axis parallel to the longitudinal direction of the linear elastic members 9a through 9f) in the tilting direction Ti illustrated in Fig. 2. At this time, as the two sets of the linear elastic members 9a through 9c, and 9d through 9f are arranged with each lying in a respective cylindrical surface, they are twisted in the tilting direction Ti while keeping almost the same length. Thus, when the holder 2 rotates in the tilting direction Ti, the bending force generated in the longitudinal direction of the linear elastic materials 9b and 9e disposed in the center positions can be decreased. As a result, it becomes possible to stably tilt the holder 2 in the tilting direction Ti. As the distortion of the linear elastic members 9a through 9f in the tilting control is limited to only bending distortion, the three directional controls, i.e., the focusing control, the tracking control and the tilt control, can be stably performed.

[0015]

As seen from Fig. 3B and Fig. 4, the optical actuator in this preferred embodiment is configured so that the width in the height direction of the tracking-control coils 4a through 4d is narrower than the spacing between the linear elastic members 9a and 9c and between 9d and 9f, and a side of each control coil located outside the holder 2 outwardly protrudes. In the tracking control coils 4a and 4b, the area shown by A in Fig. 4 undergoes a force in the tracking direction Tk. In order to perform the tracking control effectively, it is preferable to keep an area A′ that undergoes a force in the opposite direction as apart from the permanent magnets 6a and 6b as possible. That is, by making the width of the tracking-control coils 4a and 4b wider than the width of permanent magnets 6a and 6b, the force in the tracking direction can be transmitted to the holder 2 effectively.

[0016]

In an aspect of the preferred embodiment, as illustrated in Fig. 4, the linear elastic members 9b and 9e in the center positions are arranged outward of the other linear elastic members 9a, 9c, 9d and 9f, and the width of the tracking-control coils 4a and 4b in the height direction is narrower than the spacing of the linear elastic members between 9a and 9c, and 9d and 9f, so that the width of tracking control coils 4a and 4b is made wider than the width of the permanent magnets 6a and 6b. In performing the tracking control, this allows the reaction force, that area A′ undergoes to decrease, and the driving force in the tracking direction to be transmitted to the holder 2 effectively.

[0017]

Fig. 5 illustrates a modified example of the optical actuator in this preferred embodiment. Also, Figs. 6A and 6B illustrate a top surface view and a side view of the optical actuator in Fig. 5. The optical actuator illustrated in Figs. 5, 6A and 6B drives the holder 2 by one single permanent magnet 6 attached on the yoke 7.

[0018]

When one permanent magnet 6 drives the holder 2 like this, the drive point of each of the focusing control, the tracking control, and the tilting control (power points) can not coincide with the focusing lens 1 that is the driven point. The drive points of the focusing control, the tracking control, and the tilting control are each on the portion of the focusing-control coil 3, tracking-control coils 4a and 4b, and tilting-control coils 5a and 5b that faces the permanent magnet 6. In performing each control, with longer distance between the drive point and the driven point, the driving force is transmitted to the driven point indirectly. As a result, the control

becomes unstable. This problem can be solved by adjusting the position of the supporting members 2c and 2d. That is, the supporting members 2c and 2d are arranged at the suitable position between the drive points of the focusing control, the tracking control, and the tilting control and the driven point of the focusing lens 1. Furthermore, a counterweight may be provided so that the center of gravity of the holder 2 is put in to position suitable for preventing unnecessary wobble therein. Using one permanent magnet 6 can decrease the cost.

[0019]

Fig. 7 illustrates another configuration of a moving member 14. In the moving member 14 illustrated in Fig. 7, a tracking coil 4c is provided with one coil. Thus by using one tracking coil, the cost can be decreased.

[0020]

Fig. 8 is an oblique view illustrating other modified example of an optical actuator. The width of a permanent magnet 6c of the optical actuator illustrated in Fig. 8 is made wider than the width of the permanent magnets 6a and 6 of the optical actuator illustrated in Figs. 1 and 5.

As illustrated in Fig. 9 corresponding to Fig.8, areas A' of the tracking-control coils 4f and 4g are arranged in a space excluding that between the linear elastic members 9b and 9e, in order to maintain a distance from the permanent magnet 6c. Thus, when the width of the permanent magnet 6c is made wider, the amount of magnet flux acting on the focusing coil 3, and tilting coils 5a and 5b increases. As a result, sufficient driving force can be obtained for the focusing control and the tilting control. Also, with regard to the tracking coils 4f and 4g, when the tracking control is performed, the areas A' that undergo the reaction forces are situated

in the space excluding that between the linear elastic members 9b and 9e. As a result, the driving force in the tracking direction Tk can be transmitted to the holder efficiently, and stable tracking control can be performed.

[0021]

According to the aforementioned optical actuator related to the invention, the linear elastic members 9a through 9c, and 9d through 9f that support the holder 2 are connected to the support member 2c and 2d in an approximately circular arc, therefore the bending force generated in the longitudinal direction of the linear elastic materials 9b and 9e disposed in the center positions decreases. As a result, stable tilting control can be performed.

Also, as the linear elastic members 9a through 9c and 9d through 9f are arranged in circular arcs, the width of the tracking coils 4a through 4d is made wider than that of the permanent magnets 6a and 6b, and generation of force oriented oppositely to the tracking direction is prevented. As a result, stable tracking control can be performed.

Also as illustrated in Figs. 5 through 8, reduction of the permanent magnets and the tracking coils into just one part each results in the production cost being decreased.

[0022]

[Effect of the Invention]

According to an optical actuator as defined in claim 1, by the linear elastic members are connected to fixing elements that are disposed in an approximately circular arc on each of the support members, the holder is supported reciprocably in the axial direction, the disk radial direction, and the rotatably on the axis, therefore the bending force generated in the longitudinal direction of the linear

elastic materials decreases. As a result, focusing control, tracking control and tilting control can be performed stably.

[Brief Description of the Drawings]

Fig. 1 is an oblique view illustrating an optical actuator in a preferred embodiment according to the present invention;

Fig. 2 is an exploded oblique view illustrating the optical actuator;

Figs. 3A and 3B are views illustrating a top side and a lateral side of the optical actuator;

Fig. 4 is a side view illustrating a moving member of the optical actuator;

Fig. 5 is an oblique view illustrating the optical actuator in another embodiment according to the present invention;

Figs. 6A and 6B are views illustrating a top side and a lateral side of the optical actuator.

Fig. 7 is an oblique view illustrating the optical actuator;

Fig. 8 is an oblique view illustrating the optical actuator in still another embodiment according to the present invention;

Fig. 9 is a side view illustrating a moving member of the optical actuator;

Fig. 10 is an oblique view illustrating a conventional example of an optical actuator; and

Fig. 11 is a view illustrating the operation of the optical actuator.

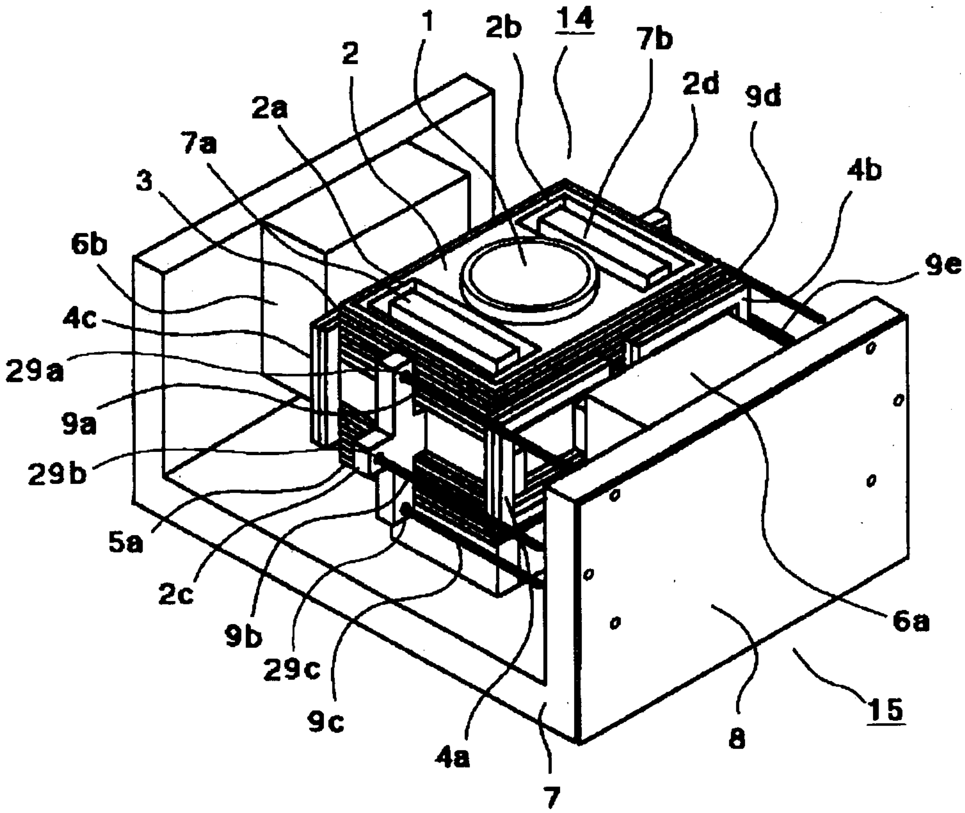
[Description of the Symbols]

1 focusing lens, 2 holder, 2a, 2b through-hole,
2c, 2d support member, 29a, 29b, 29c, 29d, 29e, 29f fixing element,
12a,12b positioning member, 20a, 20b pole, 3 focusing-control coil,

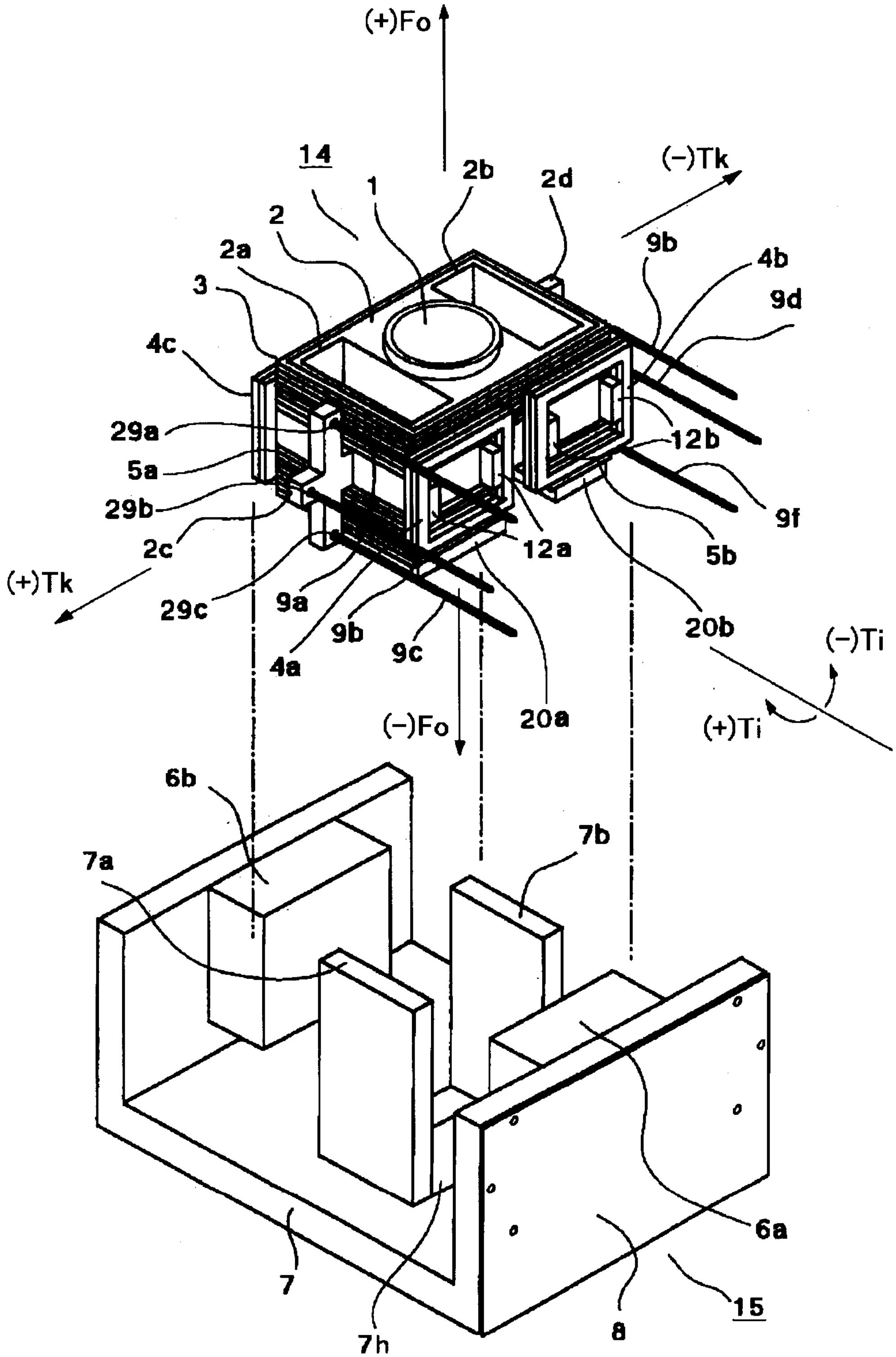
4a, 4b, 4c, 4d, 4f, 4g tracking-control coil,
5a, 5b tilting-control coil, 6, 6a, 6c permanent magnet,
7 york, 7a, 7b protrusion, 8 circuit board,
9a, 9b, 9c, 9d, 9e, 9f linear elastic member,
14 moving member, 15 holding member

[Document Title] Drawings

[Fig. 1]



[Fig. 2]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2b
2d
(−)Tk
2
2a
3
9b
4b
9d
4c
29a
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29b
2c
12a
9f
5b
(+)Tk
29c
9a
9b
9c
4a
20b
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20a
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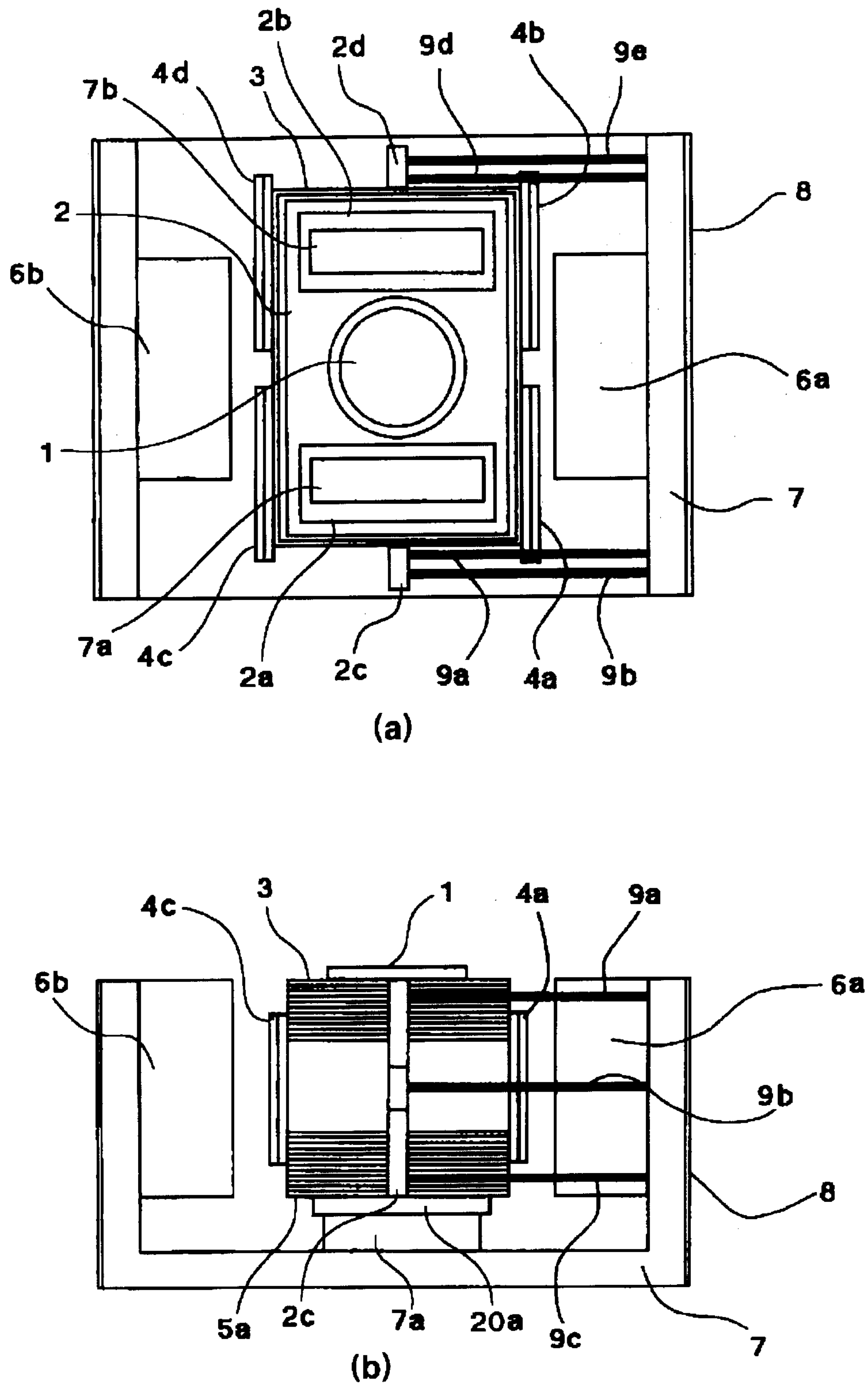
7b
7a
6a
7
7h
8
15

[Fig. 3]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2
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1
7
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2c
9a
4a
9b
(a)
3
1
4c
4a
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9b
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2c
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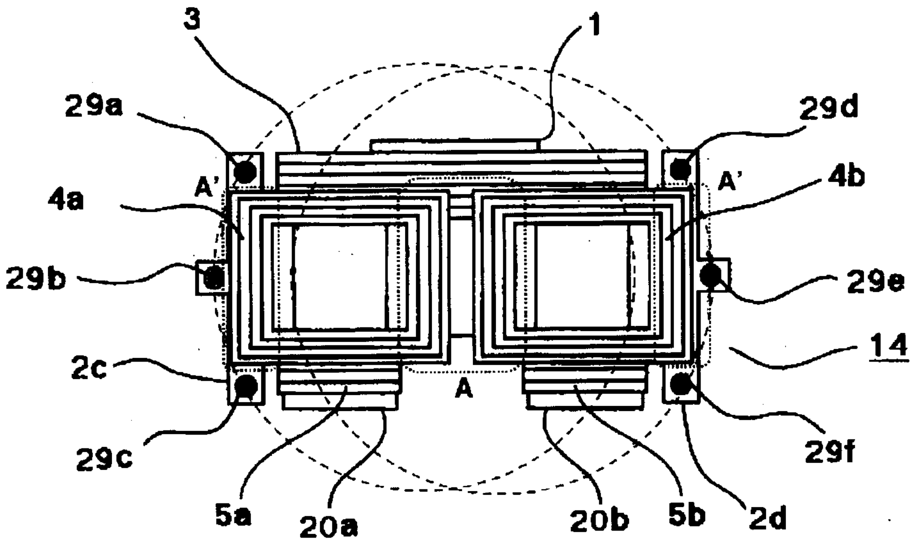
20a
9c
7
(b)

[Fig. 4]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A'
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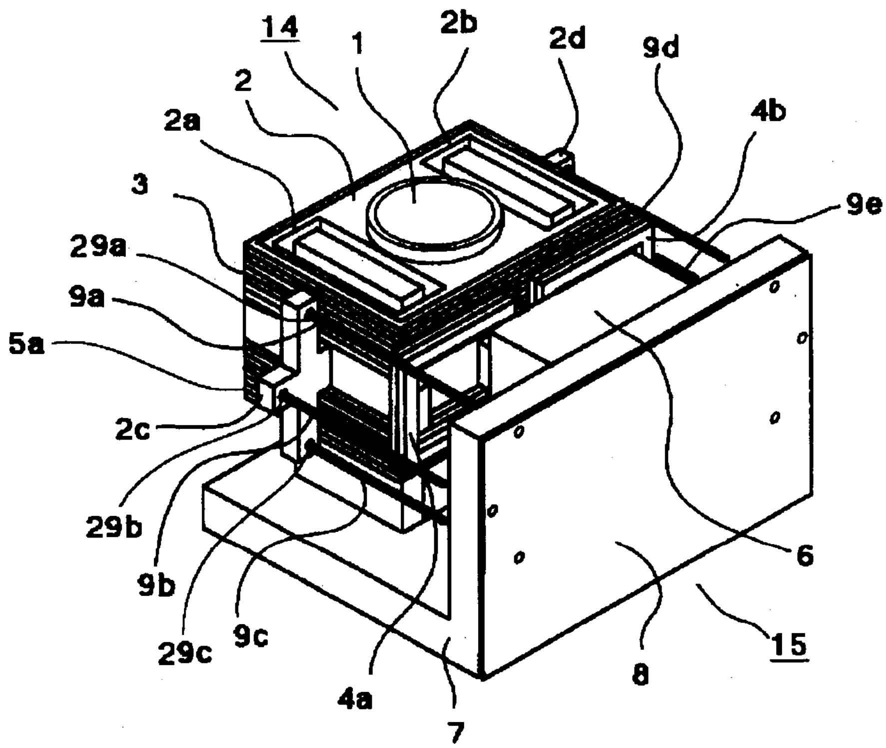
5b
2d

[Fig. 5]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2a
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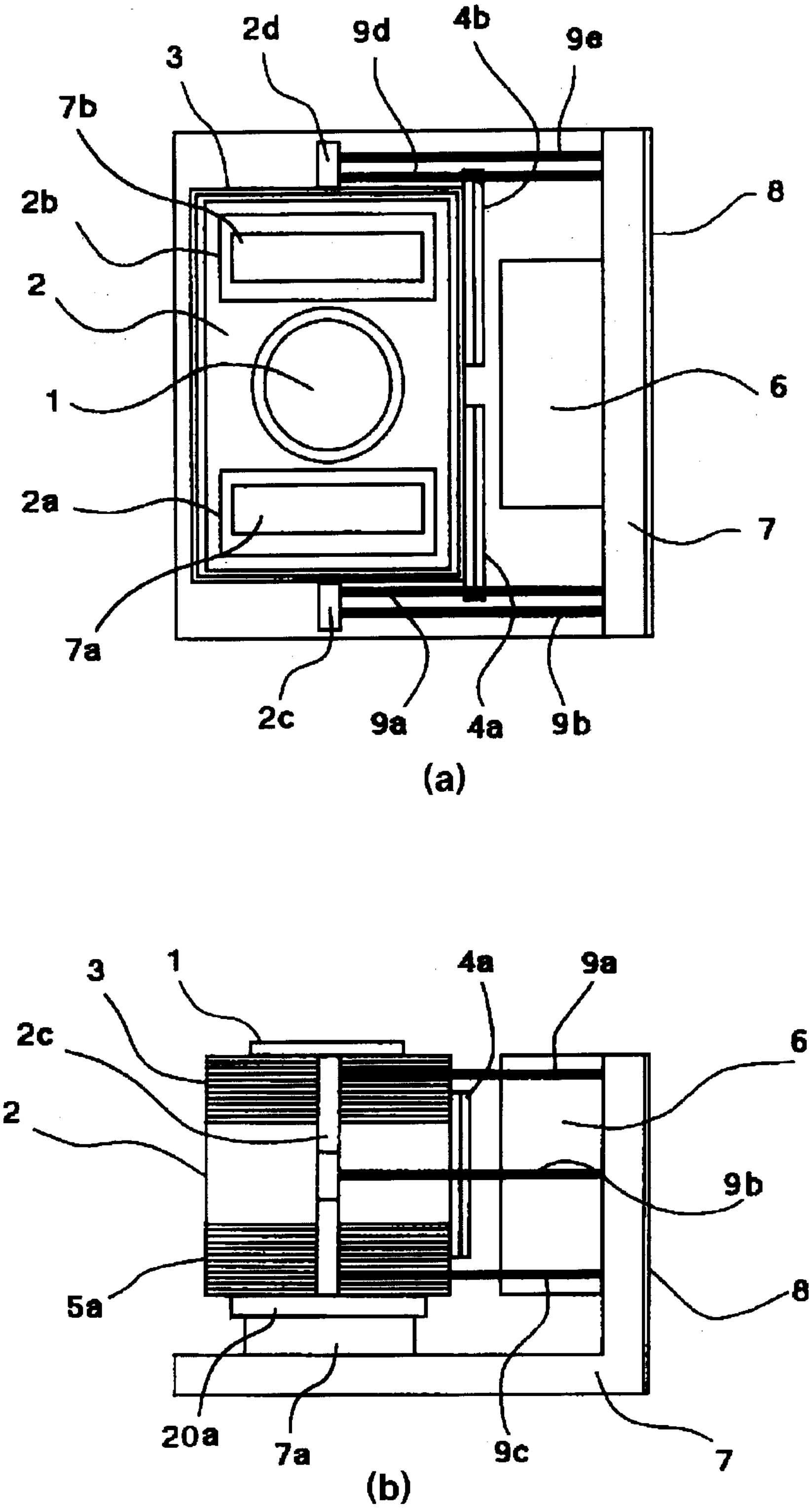
8
4a
7

[Fig. 6]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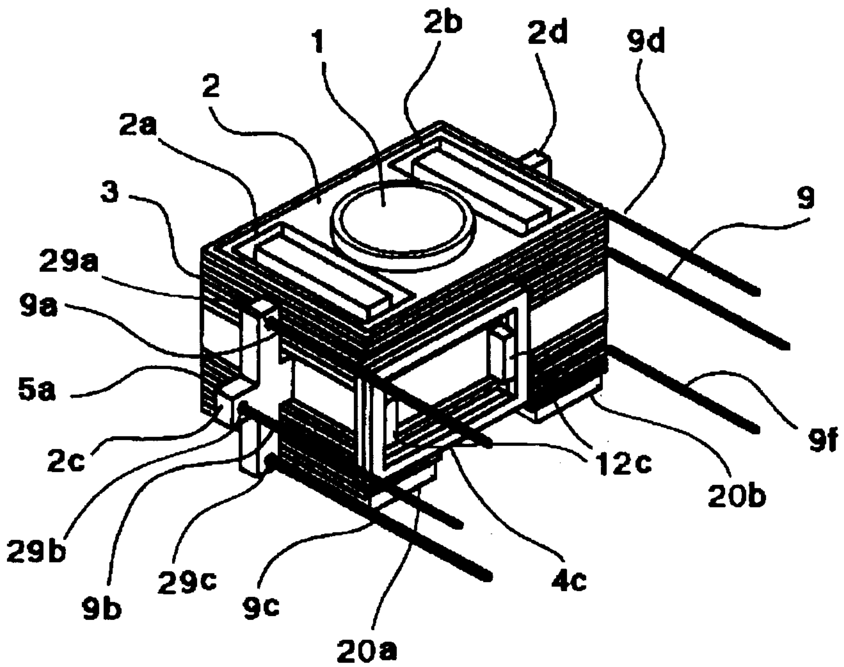
4b
9e
3
7b
8
2b
2
1
6
2a
7
7a
2c
9a
4a
9b
(a)
1
4a
9a
3
6
2c
2
9b
5a
8
20a
7a
9c
7
(b)

[Fig. 7]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2
2a
9
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2c
9f
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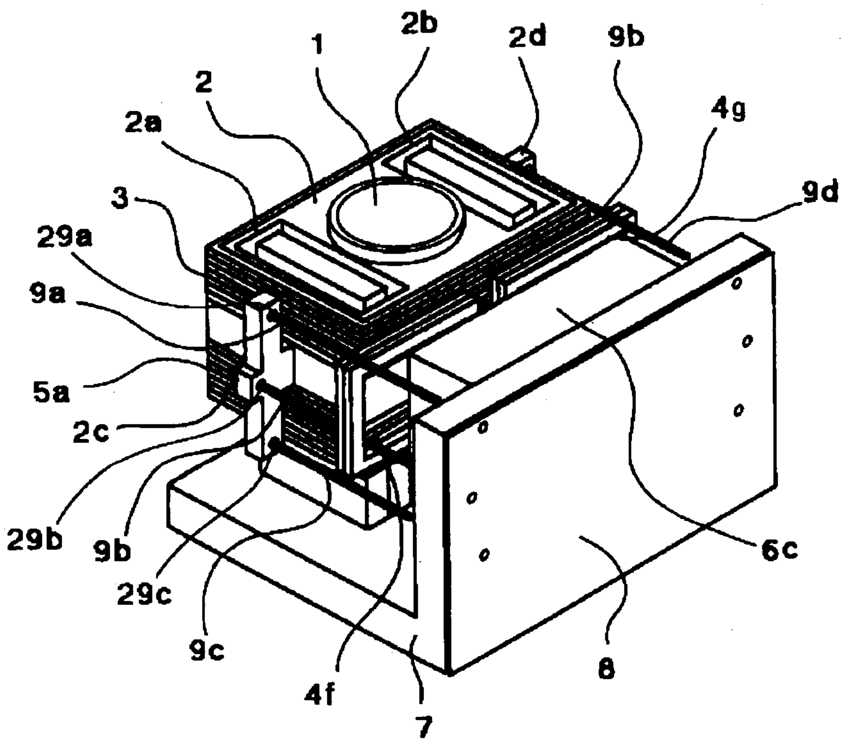
29c
9b
9c
4c
20a

[Fig. 8]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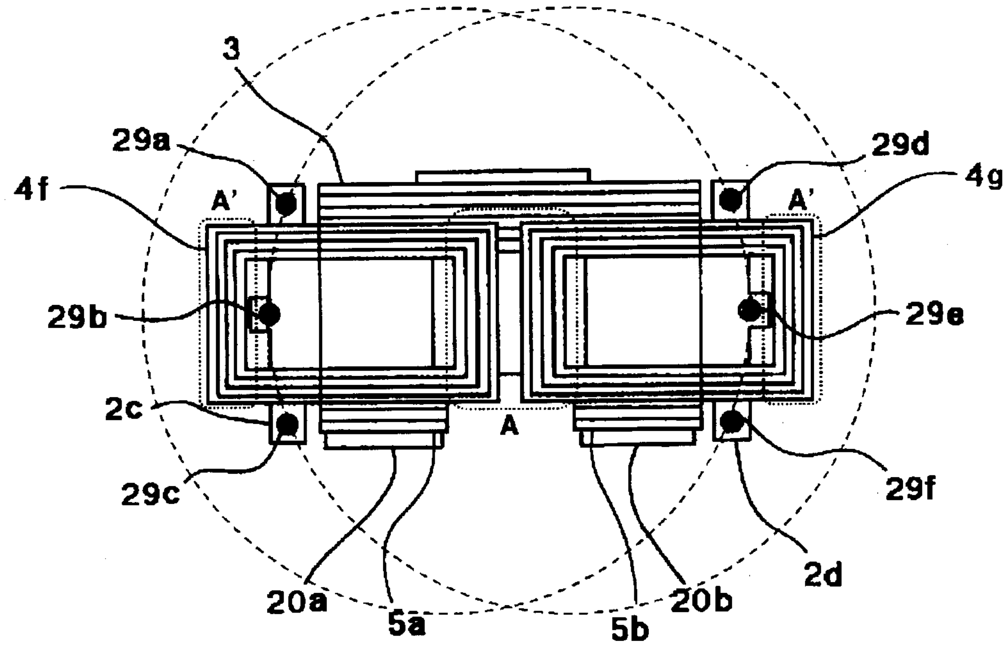
4f
8
7

[Fig. 9]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A'
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A
29c
29f
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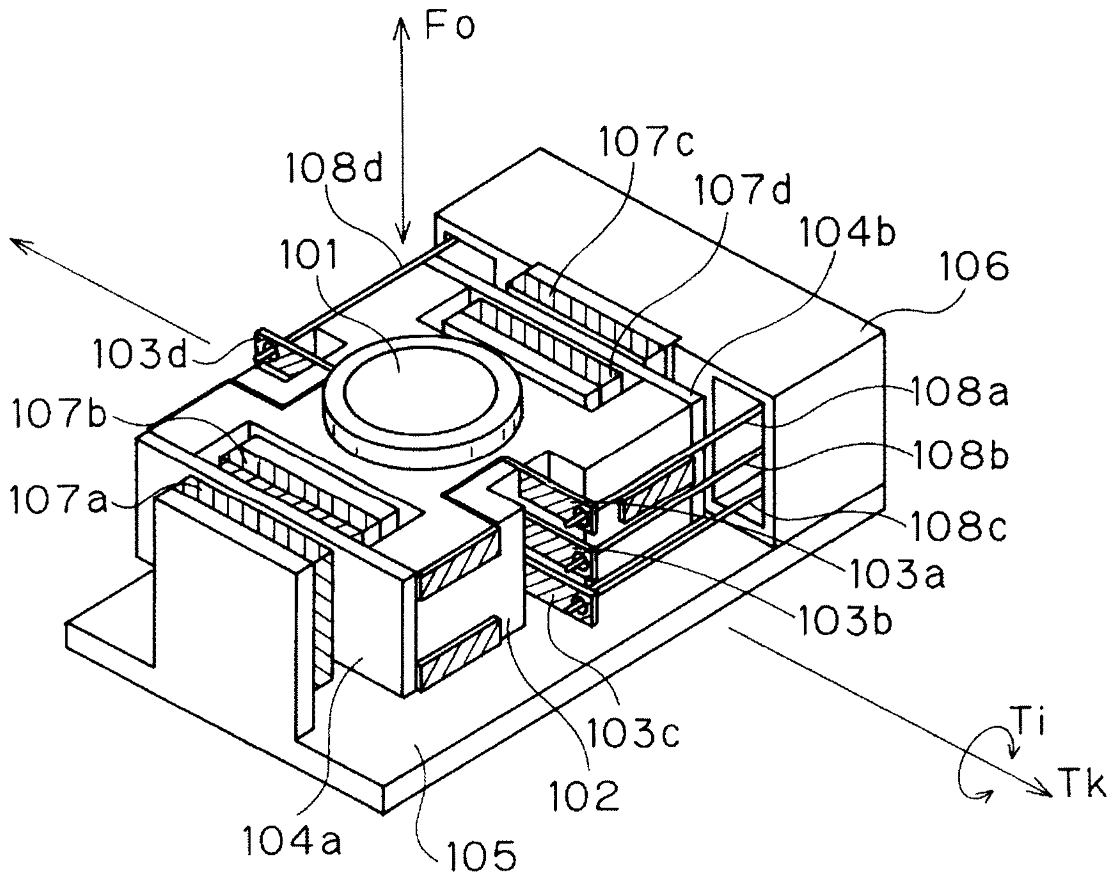
5a
5b
20b
2d

[Fig. 10]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107d
104b
101
106
103d
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108b
107a
108c
103a
103b
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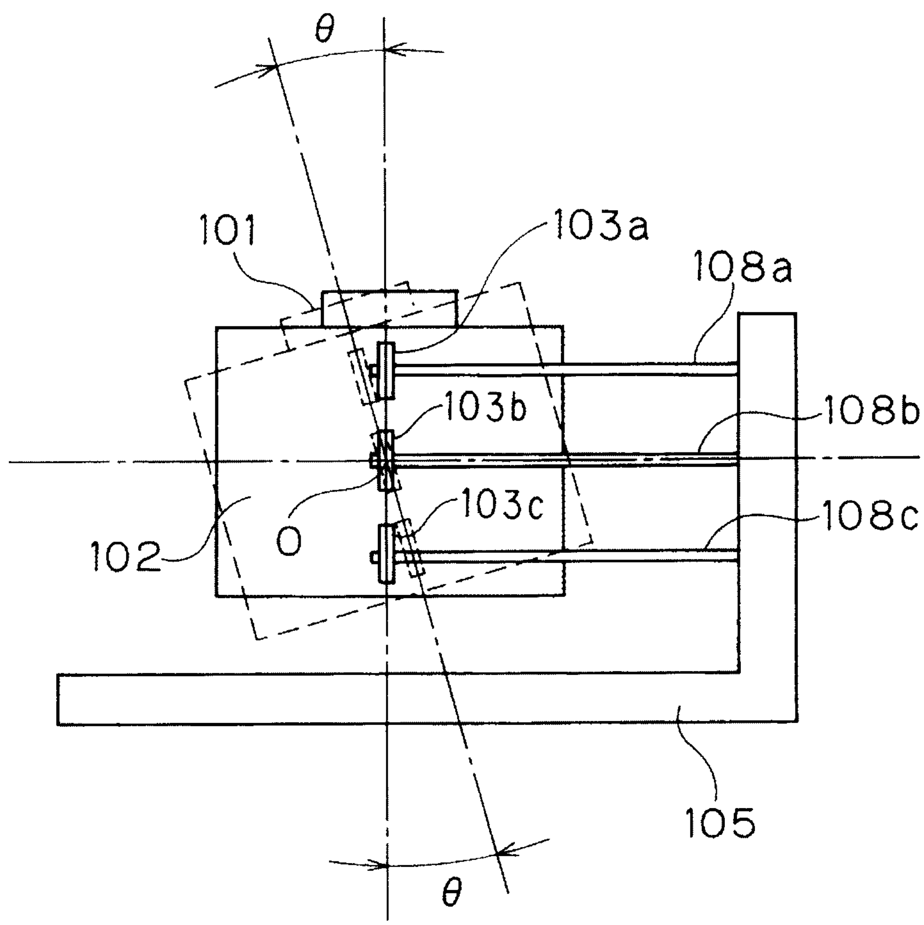
Tk
102
104a
105

[Fig. 11]



[Document Title] Abstract

[Abstract]

[Problem]

The present invention has primary objects which are to drive an optical actuator stably in three directions, that is, in the focusing direction Fo, in the tracking direction Tk, and in the tilting direction Ti, and to provide an easy-to-manufacture optical actuator.

[Means for solution] An optical actuator according to this invention includes a focusing lens for focusing a laser beam on a information disk, a lens holder for holding the focusing lens, a focusing coil for driving the focusing lens in an axial direction of the laser beam, a tracking coil for driving the focusing lens in a radial direction of the information disk, a tilting coil for pivotally rotating the focusing lens on an axis along the tangential direction of the focusing lens on an axis along the tangential direction of the disk and a pair of supporting members each disposed on each opposing sides of the lens holder. Each of the supporting members having three fixing element disposed in an approximately circular arc, and a plurality of linear members are connected to each of the fixing element.

[Selected Figure] Fig. 1